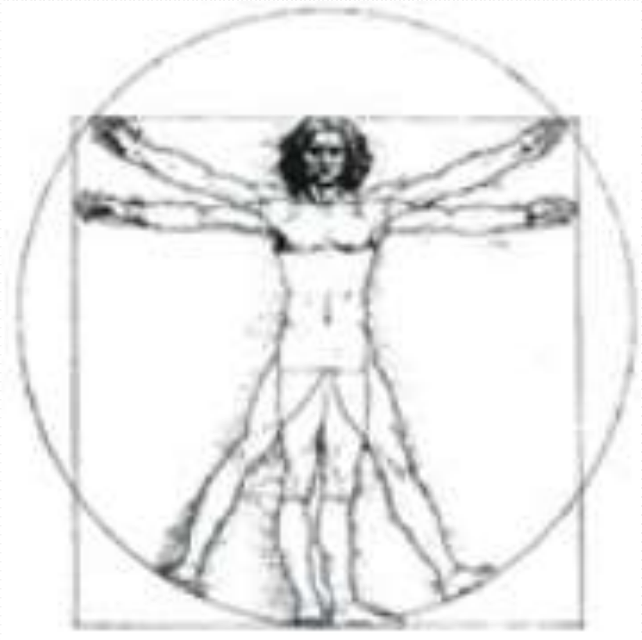
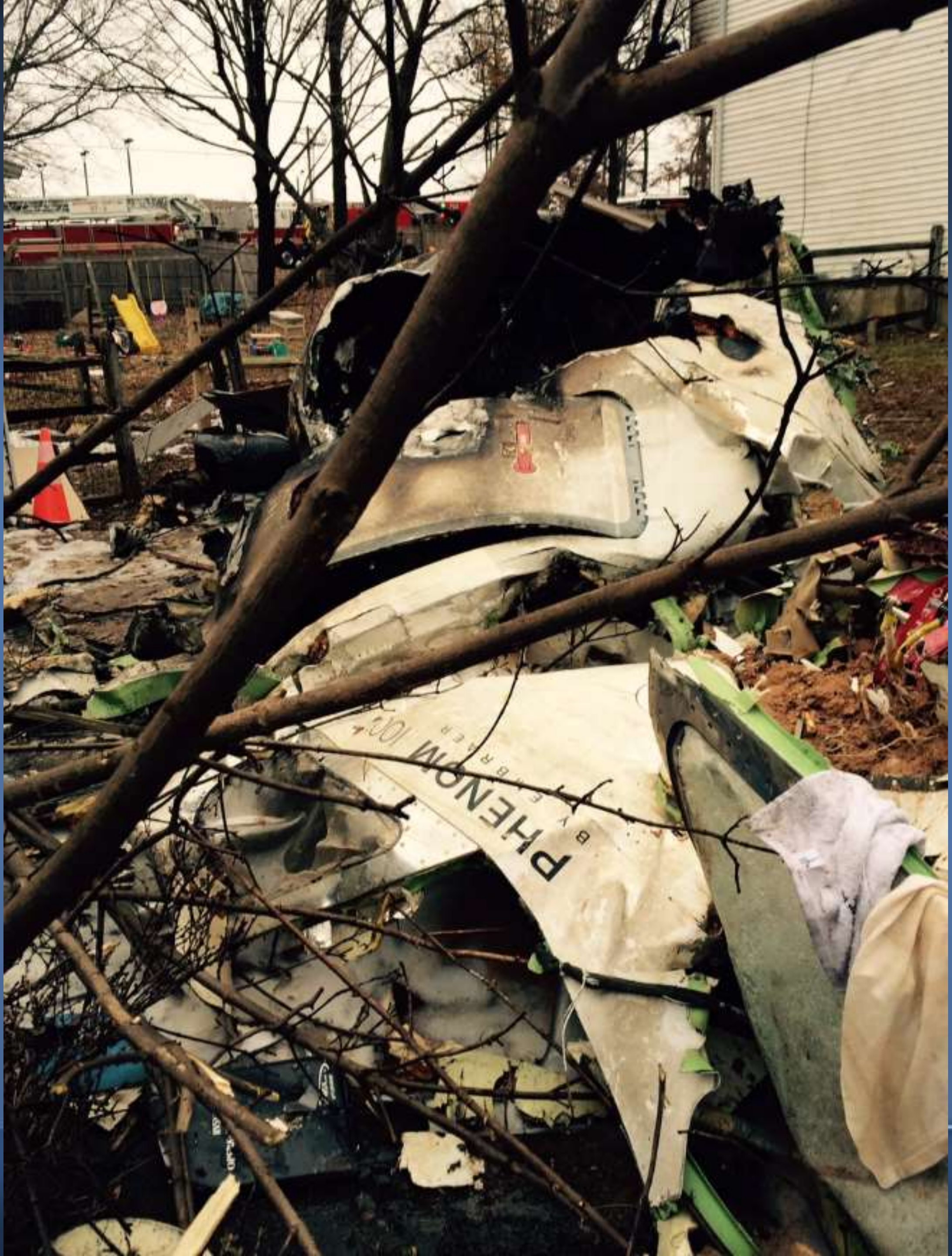
Human factors considerations for aviation safety



Robert Sumwalt


PHENOM 100

Thomson, GA
February 20, 2013

Accident aircraft prior to N-number change to N777VG.

Probable Cause

"The pilot's failure to follow airplane flight manual procedures for an antiskid failure in flight and his failure to immediately retract the lift dump after he elected to attempt a go-around on the runway."

"Contributing to the accident were the pilot's lack of systems knowledge and his fatigue due to acute sleep loss and his ineffective use of time between flights to obtain sleep."

Pilot activities

Night before trip		
	Went to bed	2100
Day of trip		
	Woke up	0200
	Departed home	0230
	Arrived airport	0330
	Departed for Nashville	0406
	Arrived Nashville	0459*
	Lunch	1500 – 1630*
	Passengers arrived	1918*
	Takeoff Nashville	1927*
	Crash at Thomson, GA	2005

* Times converted to EST

Pilot activities

Night before trip		
	Went to bed	2100
	5 hours	
Day of trip		
	Woke up	0200
	Departed home	0230
	Arrived airport	0330
	Departed for Nashville	0406
	Arrived Nashville	0459*
	Lunch 14 hours	1500 – 1630*
	Passengers arrived	1918*
	Takeoff Nashville	1927*
	Crash at Thomson, GA	2005

* Times converted to EST

NTSB

Time	Cell phone activity
0808	Phone call - outgoing
0813	Phone call - outgoing
0902	Phone call - outgoing
1002	Text message - outgoing
1005	Text message - outgoing
1016	Text message - outgoing
1121	Text message - outgoing
1138	Phone call - outgoing
1234	Phone call - outgoing
1251	Phone call - outgoing
1300	Phone call - outgoing
1315	Phone call - outgoing
1317	Phone call - outgoing
1324	Phone call - outgoing
1330	Phone call - outgoing
1332	Phone call - outgoing
1404	Text message - outgoing
1432	Phone call - outgoing
1501	Phone call - outgoing
1503	Phone call - outgoing
1642	Phone call - outgoing

1 Incoming call

2 Incoming calls

2 Incoming calls

2 Incoming calls

2 Incoming calls

1 Incoming call

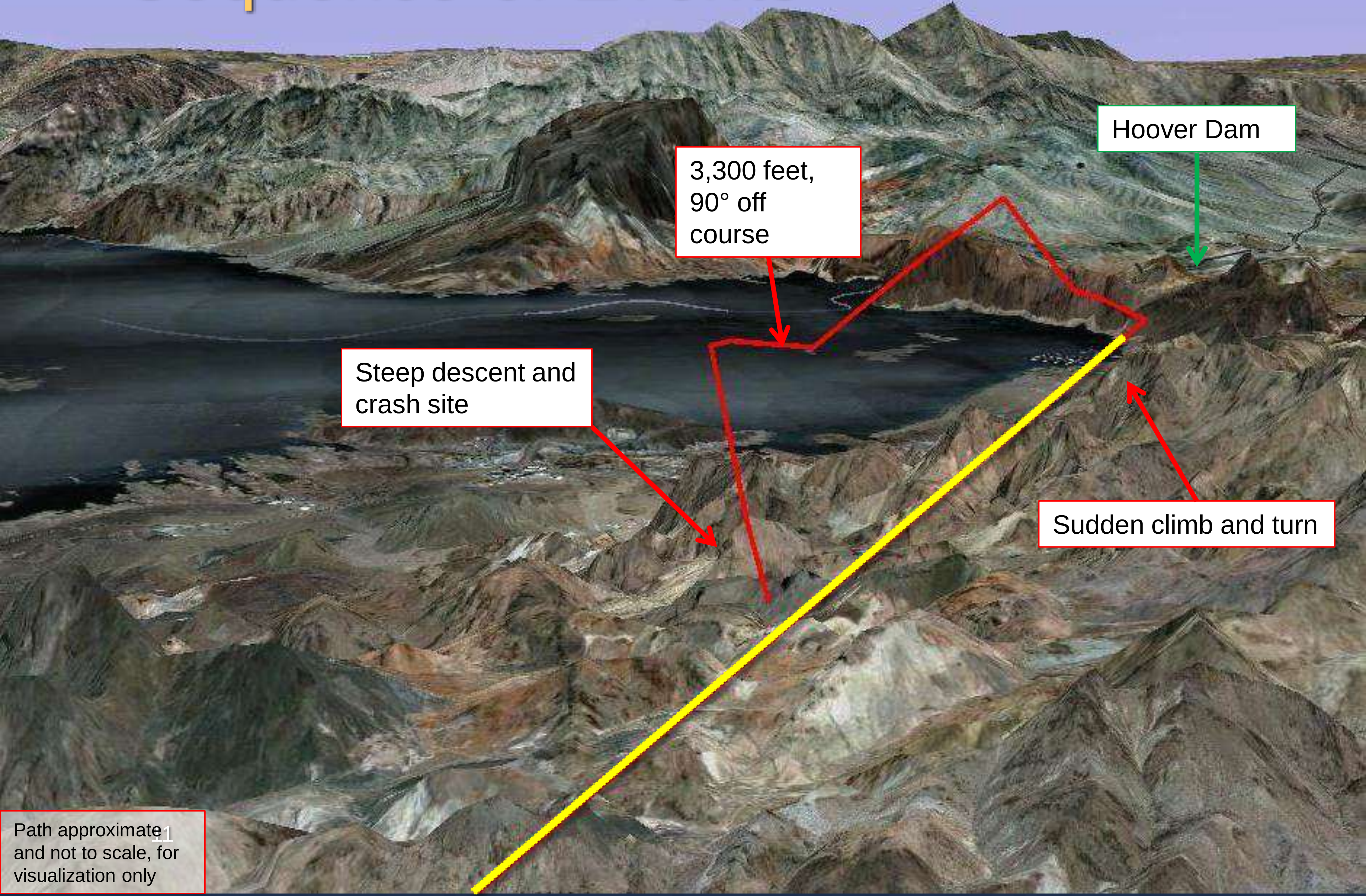
1 Incoming call

National Transportation Safety Board

Loss of Control Eurocopter AS350

Las Vegas, Nevada
December 7, 2011

Sequence of Events

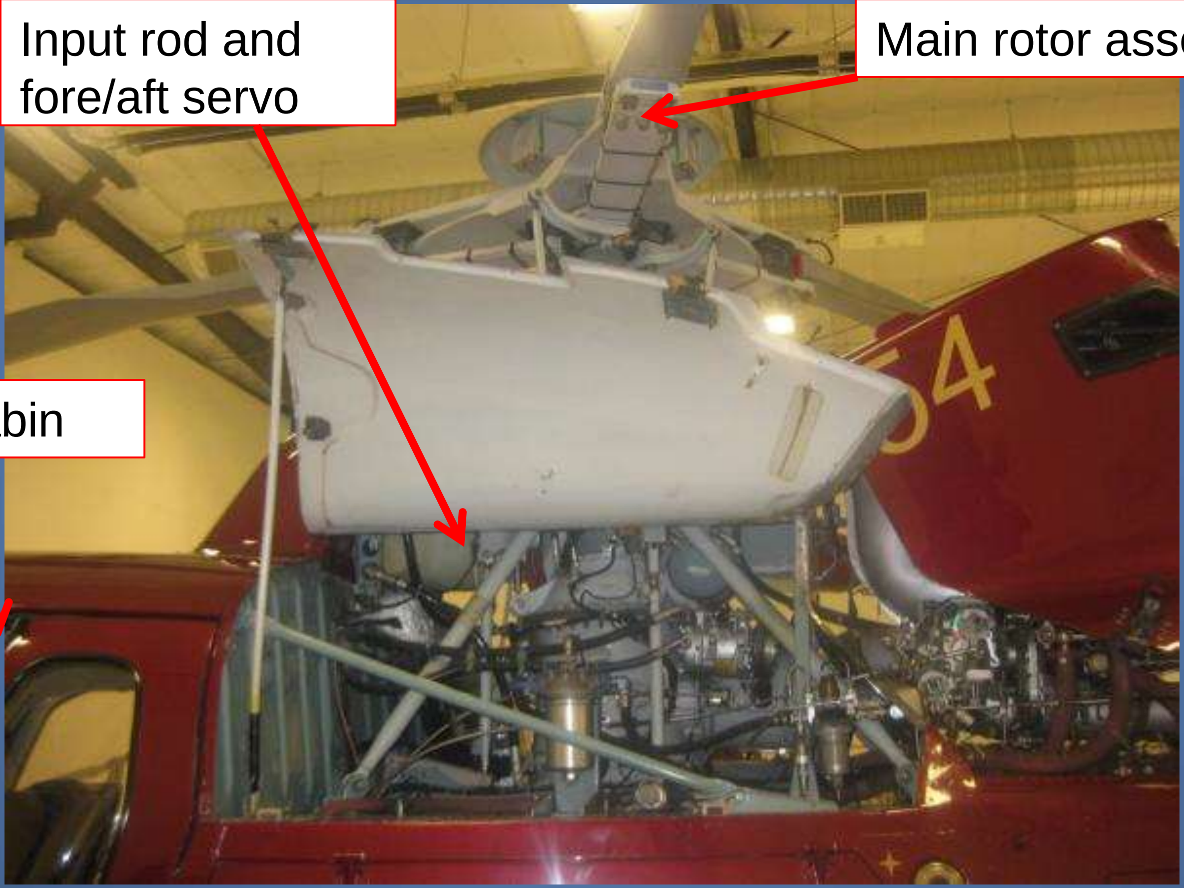


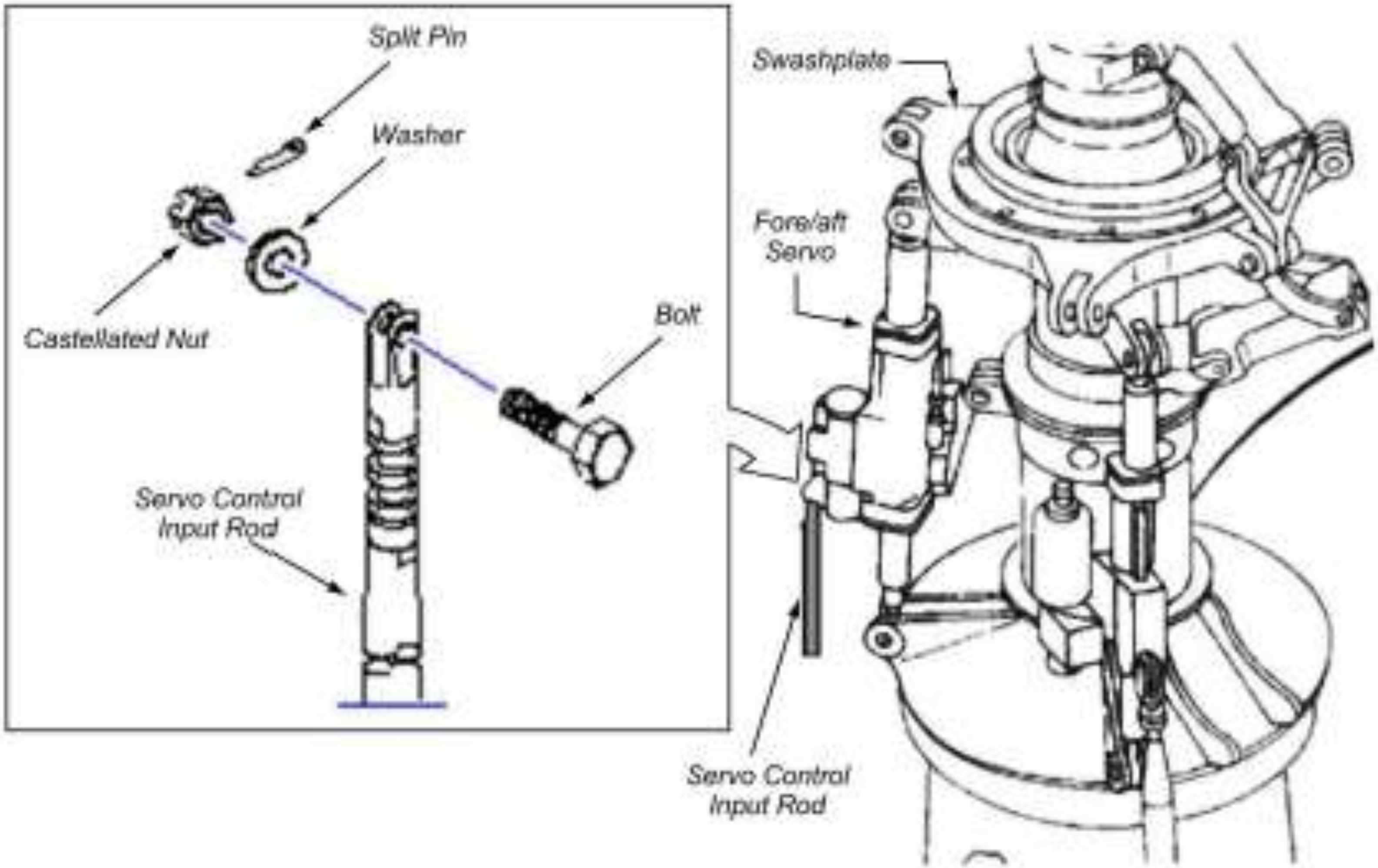

Fuselage
and engine

Maintenance Performed day prior to accident

- 100-hour inspection
- Replacement of the following:
  - Engine
  - Fore/aft and tail rotor servos

View of Helicopter Components

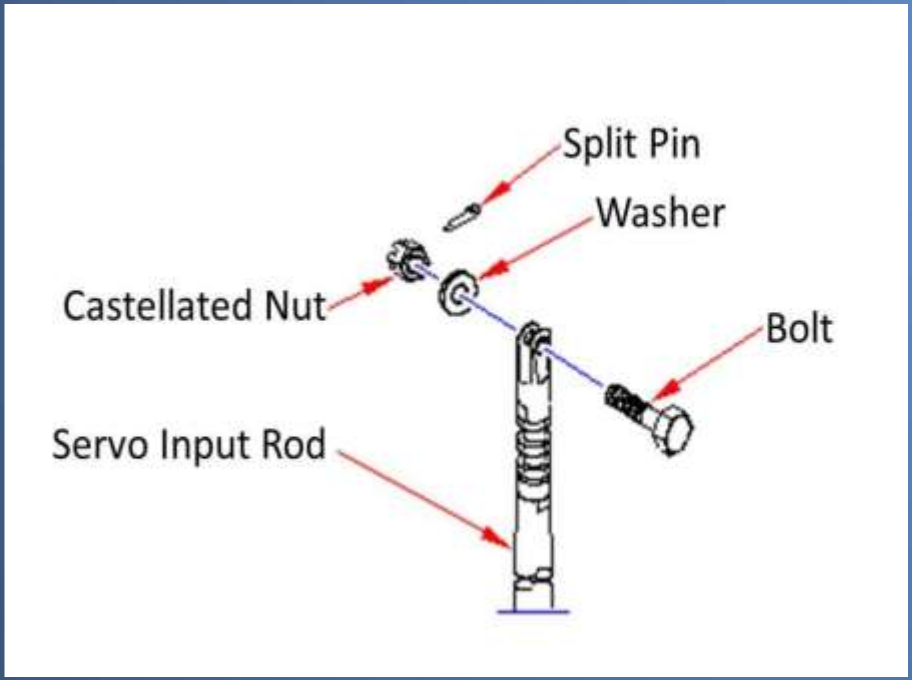



Split Pin
Washer
Castellated Nut
Bolt
Servo Control
Input Rod
Swashplate
Fore/aft
Servo
Servo Control
Input Rod

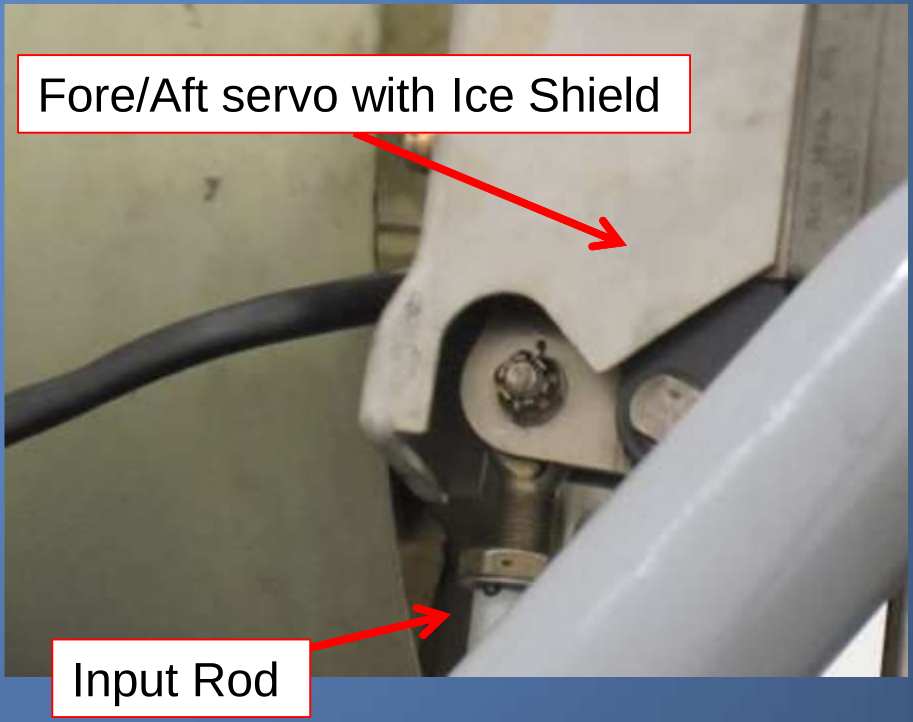
NTSB

Hardware

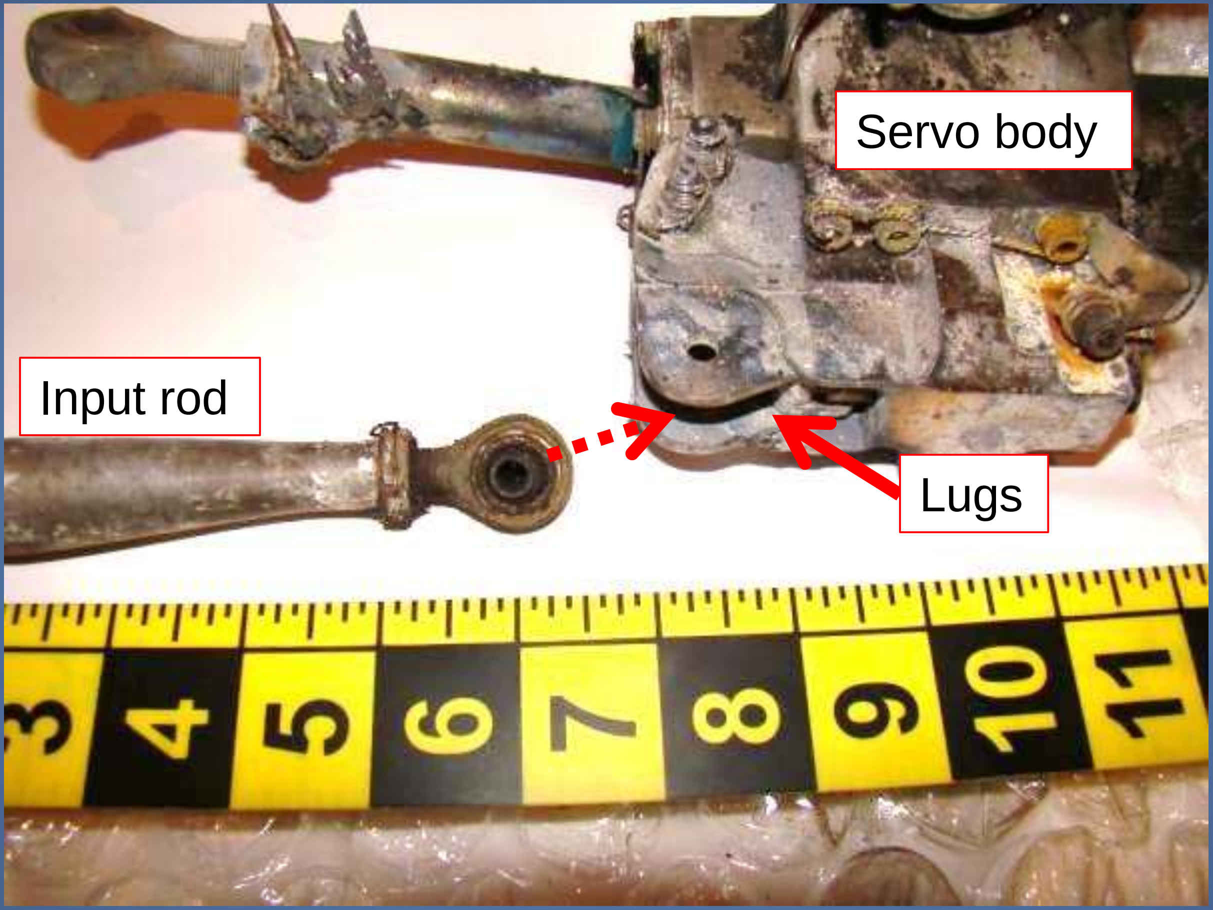
Input rod hardware



Hardware installed



Input Rod and Servo



Fore/Aft Servo Installation

- Fore/aft servo installation procedures:
  - Assess hardware
  - Connect servo to input rod
  - Torque nut
  - Install split pin
- Inspect installation

Self-Locking Nut

Acceptable Nut

Degraded Nut

Hardware Reuse

- Post accident inspection of 13 Sundance helicopters - half of nuts did not meet below requirements

Manufacturer's guidance: "If a nut can be easily tightened, it is to be discarded"

FAA guidance: "DO NOT reuse a fiber or nylon lock nut if the nut cannot meet the minimum prevailing torque values"

NTSB Finding

- The fore/aft servo bolt most likely disengaged because:
  - the split pin was installed improperly or it was not installed, and
  - a self-locking nut that either was degraded or not torqued was used
- This allowed the nut to unthread and separate from the bolt.

NTSB Finding

"The mechanic, inspector, and check pilot each had at least one opportunity to observe the fore/aft servo self-locking nut and split pin; however, they did not note that the split pin was installed improperly or not present."

Maintenance and Inspection Errors

- Improper securing of the fore/aft servo
- Improper tension of the hydraulic belt
- Incomplete maintenance inspection

Maintenance Personnel Fatigue

- The mechanic
  - Recent sleep and wake activity
  - Shift change
  - Inadequate sleep

Maintenance Personnel Fatigue

- The inspector
  - Recent sleep and wake activity
  - Shift change
  - Long duty day

Maintenance Personnel Fatigue

Personnel	Normal Shift	Shift Originally Scheduled for December 6	Actual Schedule on December 6
Mechanic	Noon to 11:00 pm	Off duty	5:50 am to 6:46 pm
Inspector	Noon to 11:00 pm	Off duty	5:31 am to 6:55 pm

Maintenance Personnel Fatigue

- Effects of fatigue
  - Difficulty sustaining attention
  - Memory errors
  - Lapses in performance

Fatigue Affects on Performance

- 2 hour sleep debt can produce performance decrements comparable to those produced by BAC of 0.045.
- 4 hour sleep debt can produce performance decrements comparable to BAC of 0.095.

Sleep loss decreases performance

- 2 hours sleep loss
  - » Productivity decreases by 17 percent

- 4 hours sleep loss
  - » Productivity decreases by 43 percent

- Source: Mark Rosekind, Ph.D.

According to experts…

"When you lose sleep or disrupt your sleep clock, every aspect of your capability as a human being is impaired."

- Mark Rosekind, Ph.D.

Rosekind says that even moderate sleep loss can result in decreases in:

» **Memory** (up to 20%)
» **Vigilance** (75%)
» **Communication skills** (30%)
» **Reaction times** (25%)
» **Judgment-making skills** (50%)

NTSB Finding

- “Because both the mechanic and the inspector had insufficient time to adjust to working an earlier shift than normal, they were experiencing fatigue during the December 6 shift.”
- “In addition, the mechanic had an inadequate amount of sleep and the inspector had a long duty day, both of which also contributed to the development of their fatigue.”

NTSB Finding

"Both the mechanic's performance and the inspector's performance probably were degraded by fatigue, which contributed to the improper securing of the fore/aft servo connection hardware, the improper installation of the hydraulic belt, and the incomplete maintenance inspection of the accident helicopter, respectively."

Enhancing Crew Monitoring and Cross-checking


U.S. NEWS
Pilots Cited in July Jet Crash
Confusion Surrounding Automation Linked to Landing Disaster in San Francisco


Pilots said to err in properly monitoring speed and trajectory.

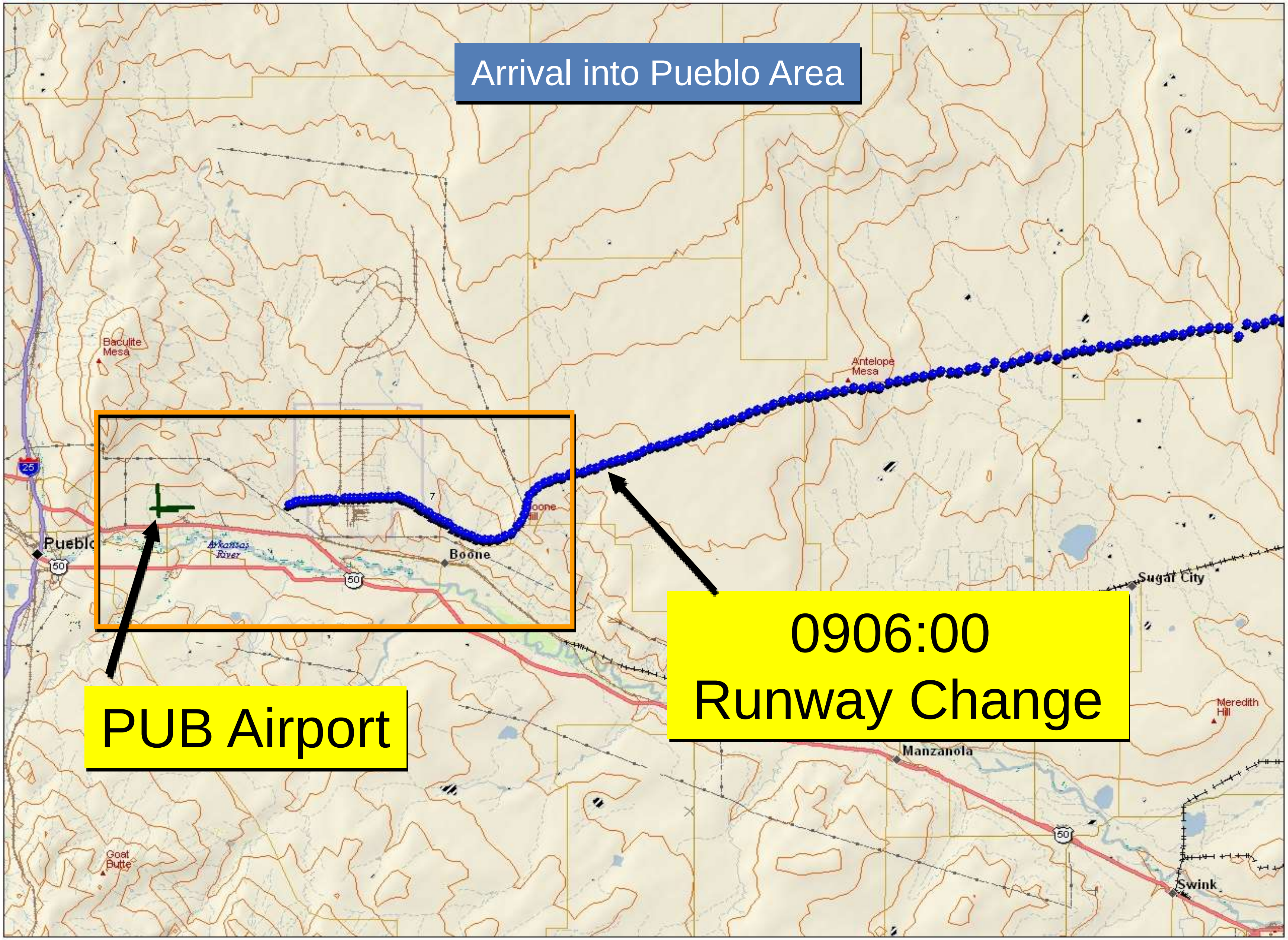
Asiana 214

"The flight crew did not adequately monitor airspeed between 500 and 200 ft."

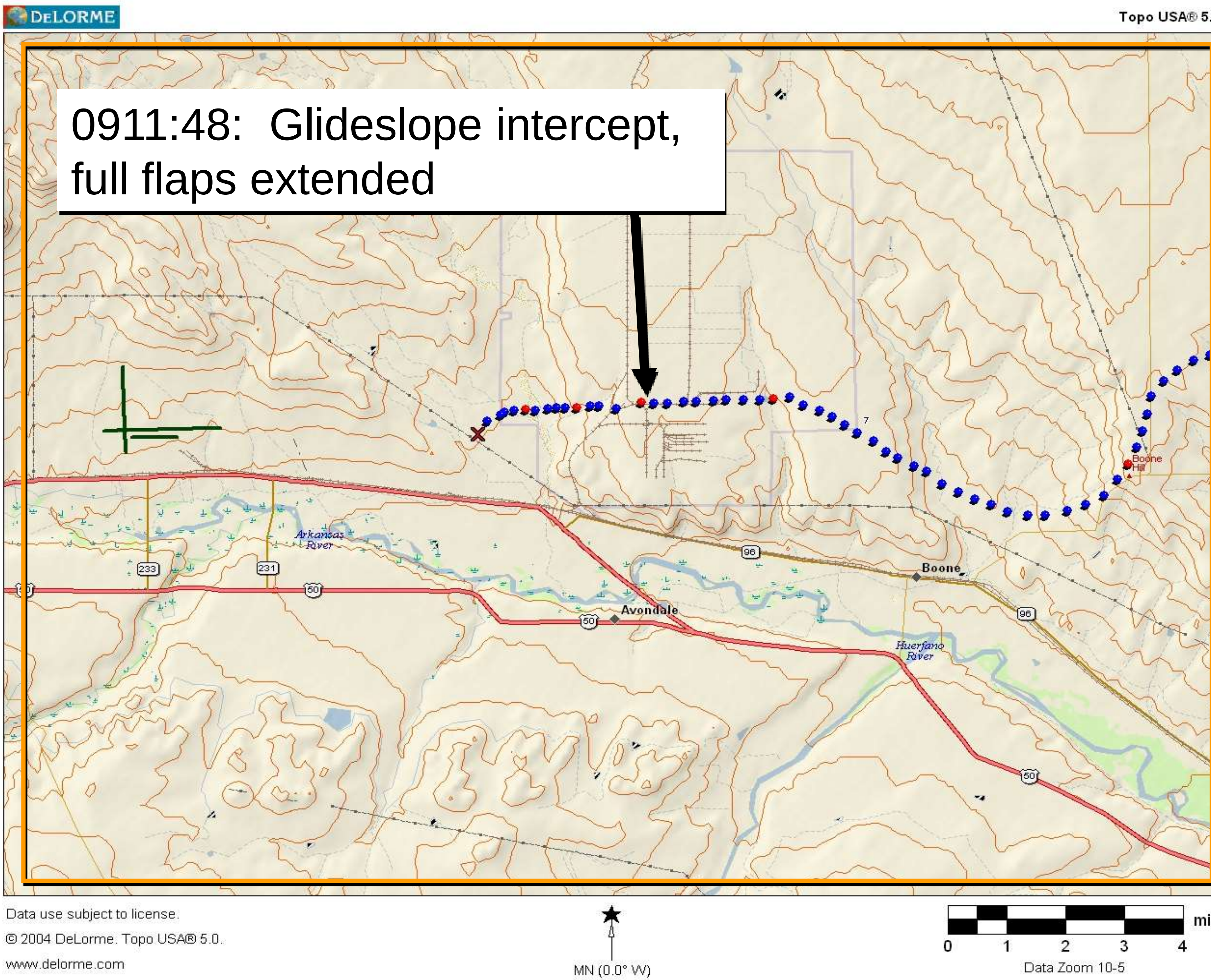
Accident Summary

- February 16, 2005
- Pueblo, CO
- Cessna Citation 560
  - Owned by Circuit City, Operated by Martinair
- Eight fatalities
- Part 91 flight

Arrival into Pueblo Area

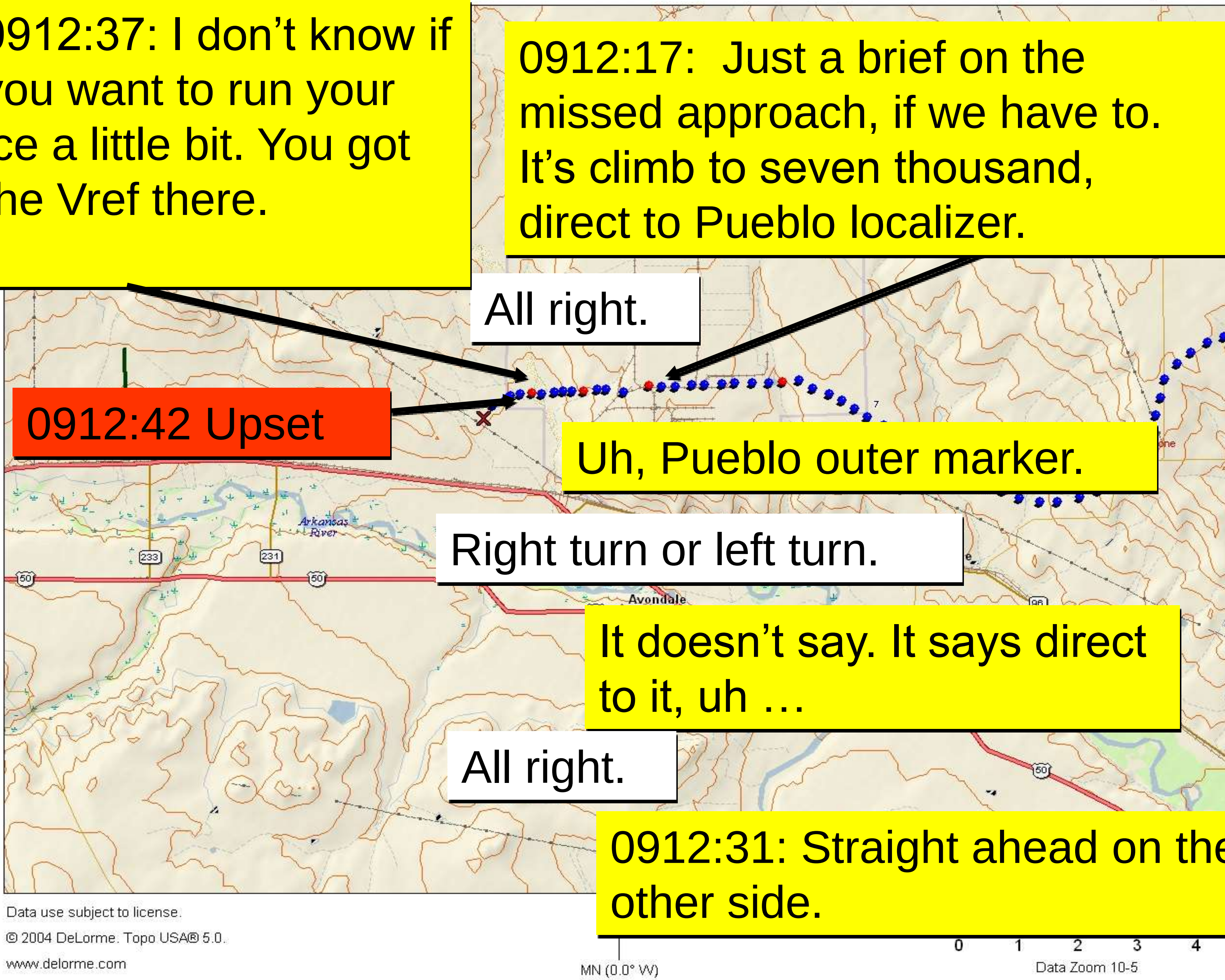


0911:48: Glideslope intercept, full flaps extended



DeLorme

Topo USA® 5.0



0912:37: I don’t know if you want to run your ice a little bit. You got the Vref there.

0912:17: Just a brief on the missed approach, if we have to. It’s climb to seven thousand, direct to Pueblo localizer.

All right.

0912:42 Upset

Uh, Pueblo outer marker.

Right turn or left turn.

It doesn’t say. It says direct to it, uh …

All right.

0912:31: Straight ahead on the other side.

Probable Cause

"Flight crew's failure to effectively monitor and maintain airspeed and comply with procedures for deice boot activation on the approach, which caused an aerodynamic stall from which they did not recover."

BARRIERS TO EFFECTIVE MONITORING

Underlying factors associated with poor monitoring

Effective monitoring is not easy and intuitive.

- It requires skill and discipline

Underlying factors associated with poor monitoring

There is somewhat of a monitoring paradox that works against effective monitoring.

- Serious errors do not occur frequently which can lead to boredom and complacency

"A low-probability, high-criticality error is exactly the one that must be caught and corrected."

Barriers to Effective Monitoring

- Distractions
- Automation reliance
- Fatigue
- High workload
- Complacency
- Runway/arrival change
- Rushing/time pressure

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Barriers to Effective Monitoring

- Looking without seeing
  - Inattention blindness
  - Change blindness
- Poor workload management/ task allocation

Change Blindness

- "People are surprisingly poor at detecting even gross changes in a visual stimulus if they occur in objects that are not the focus of attention."

  - S. Palmer, 1999, *Vision Science*.


MACH
ALT CRZ
NAV
AP1
1FD2
A/THR
280
260
240
220
10
10
375
365
370
STD
.80
4
5
6
7
8
BRT


BRT
MACH
ALT CRZ
NAV
1FD2
A/THR
300
280
260
240
220
20
10
10
375
370
20
00
80
365
STD
.80
4
5
6
7
8

Inattentional Blindness

WHAT YOU CAN DO
TO IMPROVE MONITORING

Actively Monitor

- Pilots must “actively monitor” the aircraft.

- This means you must mentally fly the aircraft, even when the autopilot or other pilot is flying.

  - Monitor the flight instruments just as you would when hand flying.

Strategically Planning Workload

- In approximately one-third of the cases studied by researchers, pilots "failed to monitor errors, often because they had planned their own workload poorly and were doing something else at a critical time."
  - Jentsch, Martin, Bowers (1997)

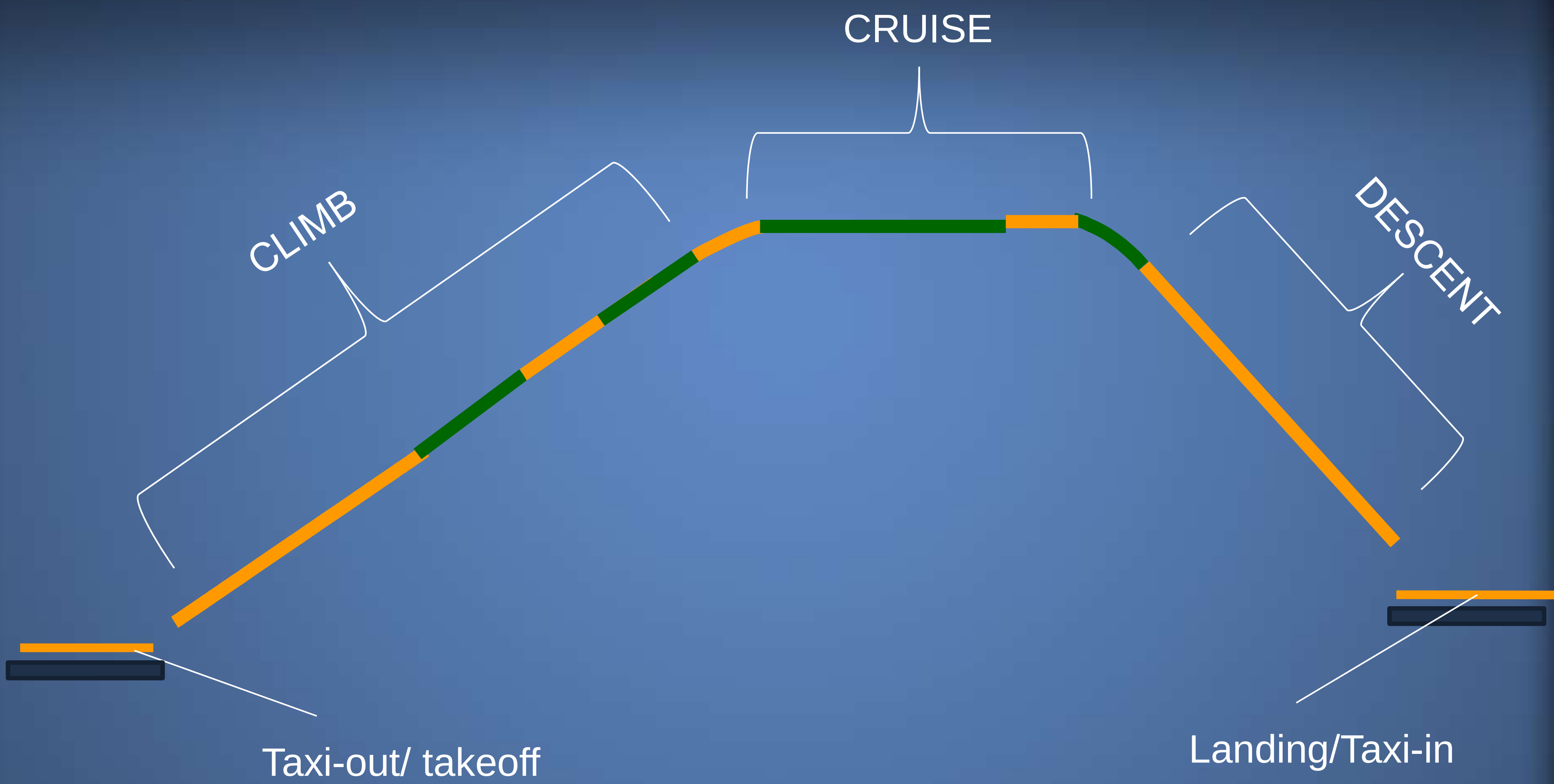
- Doing the right thing at the wrong time.

- Doing the wrong things at the wrong times.

Strategically Planning Tasks

- Pilots should recognize those flight phases where poor monitoring can be most problematic.
- Strategically plan workload / tasks to maximize monitoring during those Areas of Vulnerability (AOV)
  - Examples of non-monitoring tasks that should be conducted during lower AOV include stowing charts, programming the FMS, getting ATIS, accomplishing approach briefing, PA announcements, non-essential conversation, etc.

Areas of Vulnerability



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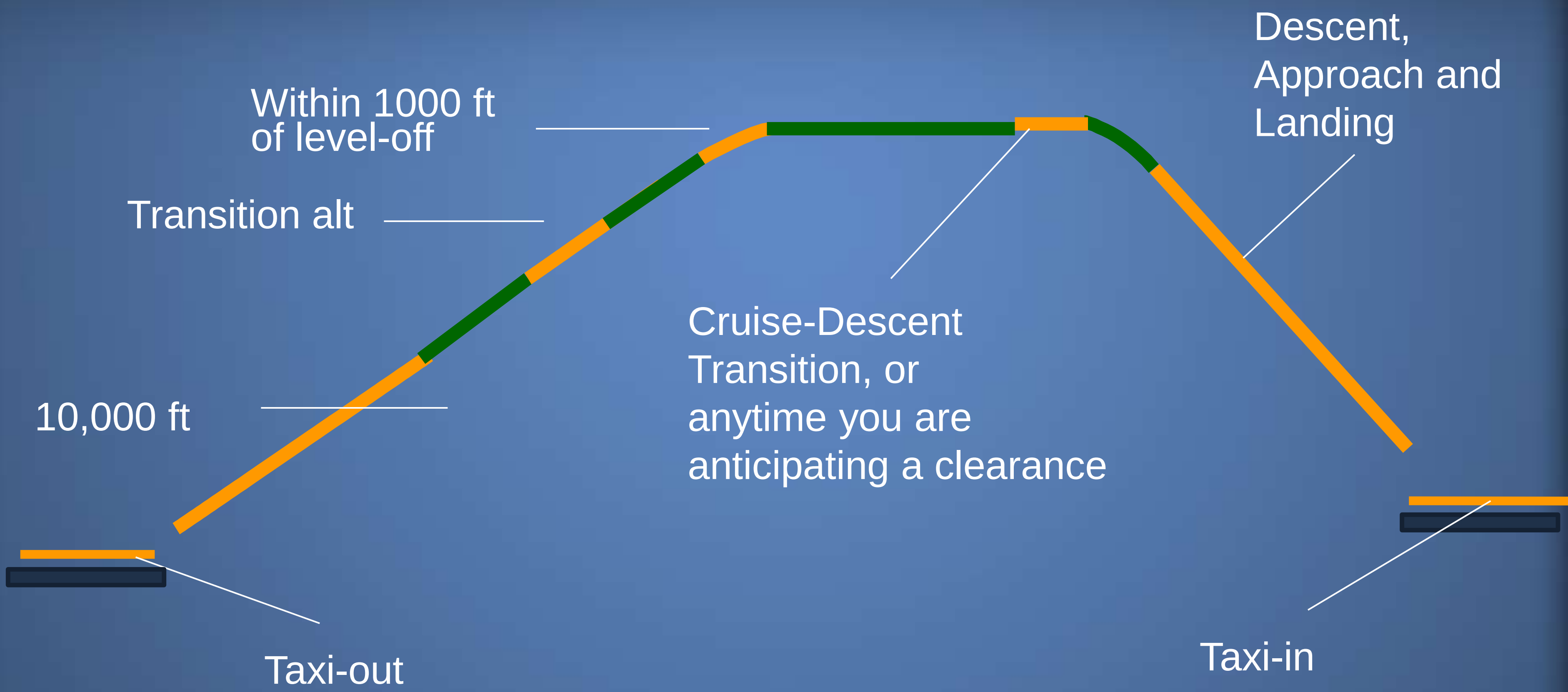
Areas of Vulnerability



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Enhancing Monitoring: Taxi

- When approaching an active runway, **both pilots** will suspend non-monitoring tasks to ensure the hold short instructions are complied with.

- Non-monitoring tasks:
  - FMS programming
  - Calling FBO
  - Checklists
  - etc.

Enhancing Monitoring: In-Flight

- Perform non-essential duties/activities during lowest workload periods (e.g., cruise altitude or level flight)

- During the last 1000 feet of altitude change, both pilots will focus on making sure the aircraft levels at the assigned altitude

Approach Briefing: Before TOD

- By briefing prior to TOD, greater attention can be devoted to monitoring during descent.
- LOSA Data: Crews who briefed after TOD averaged making 1.6 times more errors in descent/ approach/ landing phase.

How is your monitoring?

- One way of assessing your current monitoring ability is to ask: “How often do I miss making the 1,000’ to level-off altitude callout?”
  - When this callout is missed, you probably aren’t actively monitoring the aircraft.

Paradigm shift

It must become accepted that monitoring is a “core skill,” just as it is currently accepted that a good pilot must posses good “stick and rudder” and effective communicational skills.

Summary

- Inadequate flight crew monitoring has been cited by a number of sources as a problem for aviation safety.

- While it is true that humans are not naturally good monitors, crew monitoring performance can be significantly improved.

“If I had been watching the instruments,
I could have prevented the accident."

\- First Officer in fatal CFIT accident

National Transportation Safety Board